[0086] In the blocking mode of the SiC-SBD **519***y*, the highest electric field is effective at the metal-to-semiconductor interface such that charge carriers directly pass into the semiconductor body **100** without generating electron/hole pairs The SiC-SBD **519***y* breaks down without that the avalanche phenomenon occurs. As a consequence the reverse current remains comparatively low and the SiC-SBD **519***y* cannot protect the Si-IGBT **511** against overvoltage even if the SiC-SBD **519***y* would have a lower breakdown voltage. Instead, in the clamping diode **560** the avalanche breakdown generates electron/hole pairs such that the reverse current is high and the clamping diode **560** effectively protects the Si-IGBT **511** against overvoltage.

[0087] in FIG. **3**G the electric assembly **500** includes a plurality of semiconductor switches electrically connected in parallel to each other, for example two, three or more Si-IGBTs **511***a*, **511***b*, **511***c*, ... To each Si-IGBT **511***a*, **511***b*, **511***c*, . . . a free-wheeling diode **519***a*, **519***b*, **519***c*, . . . may be electrically connected in parallel. One single clamping diode **560** may be electrically connected in parallel to the two, three or more Si-IGBTs **511***a*, **511***b*, **511***c*, ... The electric assembly **500** may be integrated in an IHM (IGBT high-power module) designed for load currents of 500 A to 4 kA. housing **590** may include first sets of load terminals L**1***a*, L**1***b*, L**1***c*, . . . assigned to single Si-IGBTs **511***a*, **511***b*, **511***c*, . . . and seconds sets load terminals L**2***a*, L**2***b*, L**2***c*, . . . assigned to single Si-IGBTs **511***a*, **511***b*, **511***c*, ... The electric assembly **500** may be the high-side portion or the low-side portion of a half-bridge circuit.

[0088] In FIG. **4**A an I/V characteristic **431** of an Si-IGBT shows a maximum breakdown voltage rating V_{BR} and an I/V characteristic **432** of an SiC clamping diode of a switching assembly shows an avalanche voltage V_{AV} that is at least 10% lower than V_{BR} in a current range for which the Si-IGBT is intended to be used, e.g., for currents up to 20 A, 100 A or 200 A. In an approximately linear portion. of the I/V characteristic **432** of the SiC clamping diode through the maximum load current rating Imax, a ratio $\Delta V/\Delta I$ is at most 2 V/A for an active diode area of 2.5 mm in a steep portion of the I/V characteristic, wherein the steep portion may be defined as the part of the I/V characteristic beyond a current density of 40 A/cm^2 or with a slope of a current density per Volt of at least $1mA/mm^2/V$.

[0089] FIG. **4**B shows the I/V characteristic **431** of the Si-IGBT of FIG. **4**A and the I/V characteristic **433** of a SiC-SBD. The I/V characteristic **433** of the Si-SBD is significantly shallower than the I/V characteristic **432** of the clamping diode according to the present embodiments. Even when the Si-SBD starts to break down at a voltage similar to V_{AV} of FIG. **4**A, the voltage across the SiC-SBD may rise to above the breakdown voltage VER of the Si-IGBT such that the SiC-SBD cannot protect the Si-IGBT safely from destruction by overvbltage events, because in the SiC-SBD breakdown occurs in a junction termination or the Schottky barrier breaks down.

[0090] The clamping diode **560** uses the avalanche breakdown to limit the voltage across the switching device **510**. Typically, SiC diodes are designed to meet requirements concerning forward resistance and switching losses. If an avalanche breakdown occurs, it occurs in an edge region of a semiconductor body of the SiC diode such that the whole avalanche current flows only in a comparatively small portion of the semiconductor body. The semiconductor crystal can locally overheat and can be irreversibly damaged.

[0091] In FIG. **4**C curve **431** shows the I/V characteristic of a silicon clamping diode at T=25 degree Celsius and curve **432** the I/V characteristic of the same diode at a maximum operating temperature. The silicon clamping diode can be used to protect a switching device with a maximum breakdown voltage rating VBRIGBT**1**.

[0092] FIG. **4**D shows equivalent, curves **441**, **442** for a SiC clamping diode at T=25 degree Celsius and at the maximum operating temperature. The lower shift of the I/V characteristic with increasing temperature results in that the switching device can be selected with lower maximum breakdown voltage rating VBRIGBT**2** Typically, an IGBT with lower maximum breakdown voltage rating can be realized with lower conduction and switching losses.

[0093] FIG. **5**A shows a clamping diode **560** configured to sustain repetitive avalanche breakdowns in typical applications for power conversion and motor driving.

[0094] A metal anode **310** directly adjoins to a first surface **101** at a front side of a semiconductor body **100**. The metal anode **310** may include a Schottky barrier layer **311** of a first metal and a contact layer **312** of a second metal. The metal anode **310** forms or is electrically connected to an anode terminal A.

[0095] A cathode metal **320** directly adjoins to a second surface on the back opposite to the first surface **101**. A lateral outer surface **103** tilted to the first and second surface **101**, **102** connects the first and second first surfaces **101**, **102**. The metal cathode **320** forms or is electrically connected to a cathode terminal K and directly adjoins to a heavily n-doped cathode region **129** forming an ohmic contact with the metal cathode **320**.

[0096] Between the first surface **101** and the cathode region **129** the semiconductor body **100** may include a lightly or medium n-doped drift zone **121** and field shaping structures **130**. In case a reverse voltage is applied between the metal anode **310** and the metal cathode **320** the field shaping structures **130** shape the electric field such that the maximum electric field strength is in a region distant from the first surface **101**. The semiconductor body **100** may also include heavily p-doped anode zones in ohmic contact with the metal anode **310**.

[0097] In a central region **610** both the metal anode **310** and the metal cathode **320** directly adjoin to the semiconductor body **100** and the semiconductor body **100** is sandwiched between the metal anode **310** and the metal cathode **320**. In the central region. **610** a forward current I_{Fwd} flows in a vertical direction through the semiconductor body **100**. In a termination region **690** separating the central region **610** from the outer surface **103** an interlayer dielectric **210** separates the metal anode **310** from the semiconductor body **100**. In the termination region **690** a forward current vector has a component horizontal to the first surface **101** and no charge carriers pass through the first surface **101**.

[0098] The clamping diode **560** according to the embodiments clamps the avalanche breakdown within the central region **610**. Since the central region **610** is comparatively homogeneous, the avalanche current can quickly spread across the whole central region **610**. Local overheating can be avoided and the clamping diode **560** shows sufficient avalanche ruggedness against repetitive, periodic avalanche breakdowns.